

## CLAIMS

A Miniaturized Waste Heat Engine (MWHE), able to recuperate waste energy from any heat source and convert it into useful energy formed by:

1. A miniaturized waste heat engine formed by special converters, expanders, imploders, and air/oxygen compressing systems; said expanders can be coupled with an air compressing system forming an oxygenator, and or with a work producing unit to convert waste energy into useful energy; said expander can be insulated from the air compressing system and/or by the surrounding environment by low thermal conductivity materials and/or a vacuum; said expander can also have internal cooled chambers or paths for sudden condensation/implosion; said expander contains one or more miniaturized wheels; said wheels can be specially bladed wheels or wheels formed by multiple stages of blades assembled inside the same wheel; said wheel is connected to a shaft, said shaft is connected to a compressor wheel only, or to a compressor wheel and an exhaust gases wheel; said compressor wheel can be flipped 180° forming a perfectly symmetrical device; said oxygenator is driven by a working fluid circulating in a closed loop of said miniaturized waste heat engine; said fluid is superheated by rapid heat transfer converters, said closed loop can be independent of the closed loop formed by the cooling system of the engine or power system providing the waste heat; said working fluid flows, accelerates and becomes superheated vapor inside said converters which have compact dimensions; the mass flow rate of said working fluid is regulated by a computer which controls the mass of said superheated vapor inside said expander and/or work producing units by means of a pump, valves, and active actuators; said oxygenator and/or work producing units can be operated in a pulsed manner or in a continuous mode depending on the amount of excess energy produced by said converter(s) and/or the settings of said computer; said excess energy can also be utilized by a power unit to be coupled to any load or it can be accumulated inside a tank thermally insulated by insulating materials and/or by a vacuum.

2. A miniaturized waste heat engine as defined in claim 1 whose miniaturized expander(s) contain one or more converging nozzles with or without active regulation of said superheated vapor; said active regulation is accomplished by varying the position of needles integrated inside the nozzle(s), and by adjusting said mass flow rate; said needles can be adjusted via computer control and actuator means, and/or by manual means; said nozzles are also positioned inside the body of said expander to generate reaction forces which minimize the wearing forces on thrust bearings; the proper combination of the following factors: wheel(s) diameter,

weight/material, number of blades, and angle of blades driven by said mass flow rate controlled by said computer, generates specific anti thrust bearings wearing forces.

3. A miniaturized expander as defined in claim 2 containing vapor imploding means or imploders; said imploding means being formed by prolonged air (or any other fluid) cooled surfaces upon which vapor exiting from said blades collapses creating sudden pressure drops; said imploders generate pressure gradients which increase the expander efficiency.

4. A miniaturized waste heat engine as defined in claim 1 in which the expander as defined in claim 2 and 3, contains speed sensors; said sensors detect the wheel speed and allow regulation of the expander(s) thermodynamic and mechanical parameters through electric, and/or hydraulic, and/or pneumatic, and/or magnetic actuators controlled by said computer; said computer, through sensors, monitors the thermodynamic state of the vapor and regulating said mass flow rate through said pump such that it can adjust the pressure output of said oxygenator(s), and/or the power output of said work producing units or said power units whose load can be the directly or indirectly coupled to their shaft.

5. A lubrication system via forced convection and forced circulation caused by the movement of the shaft of the expander as defined in claim 2 and utilized by the waste heat engine defined in claim 1; said shaft is characterized by microchannels located internally and/or on its surface; said microchannels are shaped in a way that the effect of said microchannels is as equivalent as having inner blades etched through the surface of said shaft; the combination of the bushing/bearing(s) surrounding the shaft and the shape of said inner blades allow the penetration of lubricating fluid; said inner blades impart kinetic energy to said lubricating fluid provoking a forced convective effect, or pumping effect, without need for external pumping devices for said lubricating fluid to be circulated inside said bushing/bearings; said inner blades of say one said bushing/bearing(s) can also be hydraulically connected to another set of said inner blades transferring said lubricating fluid from one set of said bushing/bearing(s) to another by making said shaft a hollow shaft; said lubricating fluid can also be cooled by cooling tanks located on said oxygenators; said cooling tanks transfer heat from the lubricating fluid to the air circulating into said compressor(s).

6. A movable and adjustable mass balancing system for said shaft of said expander as defined in claim 2 and 3 characterized by a series of masses mechanically linked to said shaft; at least one of these masses can be moved toward or away the axis of said shaft; said movable mass

provokes an off-set in the center of mass of the system formed by said shaft, said expander wheel, the compressor wheel, and the exhaust gases wheel; said movable mass can be blocked by lock-on-position means or simply by a screw.

7. A waste heat engine utilizing an expander as defined in claims 1, 2, 3, and 4; said expander is coupled on one side by a compressor body formed by a compressor casing and a compressor wheel, and on the other side by an exhaust gases wheel and its casing including the exhaust gas nozzle; said casing including the exhaust gas nozzle in its whole is surrounded by a heat chamber which constitutes one of said converters utilized in said waste heat engine; said superheated vapor can circulate inside said heat chamber without ever coming to contact with the exhaust gases; said heat chamber is also thermally insulated from the surrounding environment by means of thermally insulating materials wrapping said expander and said casing including the exhaust gas nozzle, and/or by utilizing a jacketed structure whose internal chamber is evacuated by means of a vacuum valve.

8. One or more expander lubricating fluid cooling tanks for the expander defined in claim 1; said cooling tanks are positioned on the structure of the expander and in thermal contact with the air paths of the compressor casing coupled to said expander and forming said oxygenator of said waste heat engine.

9. One or more vapor imploding chamber(s) positioned in the vapor exhaust hydraulic circuit of said expander as defined in claim 1; said imploding chambers form the imploder structure characterized by cooled chambers integrated inside the body of said expander or positioned outside said expander.

10. One heat transfer converter characterized by a heat chamber formed by a jacket surrounding the body of said exhaust gases casing; said converter is also characterized by one or more inlet/outlet ports to which insulated piping or tubing can be connected; said converter is thermally insulated by a vacuum chamber in which air can be evacuated by means of a vacuum valve; said converter allows circulation of said waste heat engine working fluid independently of the hydraulic paths inside said expander.

11. Multiple nozzles integrated inside said expander as defined in claim 1; said nozzle direct said superheated vapor to the blades of a special expander wheel; said special wheel contains multiple stage blades positioned on the same wheel but on different circumferences; said blades

of said special wheel are shaped and angled in a different way from one stage to the other so as to conserve the direction of motion of said special wheel; said multiple nozzles are positioned inside the stator of said expander and are located at different distances with respect to said shaft proportionally to the radius of each said circumference containing a specific set of said blades; said multiple nozzles are hydraulically connected internally and invert the direction of said superheated vapor generating an overall vapor reaction force used to counter balance the effect of undesired reaction forces; said nozzles are converging nozzles whose diameters are proportional to the changing thermodynamic state of said superheated vapor when expanding from one stage/circumference to the other; the number of nozzles utilized is variable and their position is symmetric with respect to said shaft; said vapor reaction force can be designed to counter balance the effects of forces originated by the fluid inside said compressor casing and inside said exhaust gas casing.

12. A symmetric oxygenator formed by a vapor expander coupled with an air/oxygen compressing system as defined in claim 1; said expander is coupled with a compressor wheel flipped with respect to the shaft of said expander, thereby forming said symmetric oxygenator; said symmetric oxygenator is characterized by a symmetrical air intake and diffuser system; said compressor wheel is mechanically linked to said shaft of said expander; said compressor wheel ejects air into a perfectly symmetrical diffuser; said symmetrical diffuser constitutes a diverging nozzle formed by two concentric cones having different height and diameter, or by a concentric cone positioned inside a cylinder; said diverging nozzle is symmetrically distributed along the surface of the inner cone; said inner cone surface is exposed to the flow of intake air which provides cooling for an imploding chamber positioned inside said cone; said cone is connected to a greater cone or cylinder surrounding said cone by fins or vanes; said vanes are shaped to re-direct the air ejected from said compressor wheel; said vanes can include hydraulic paths for inlet and discharge of said expander when said expander is positioned inside said inner cone.

13. A by-pass valve system assembled on the body of the oxygenator defined in claim 12 and utilized in the waste heat engine defined in claim 1; said by-pass valves can be positioned anywhere on the body of said oxygenator or at the discharge or air outlet of said oxygenator; said valves open when the pressure inside the oxygenator is less than the pressure outside said oxygenator; said valves are formed by membranes made of elastic materials forming a sealed structure whenever the pressure inside said oxygenator is higher than the outside pressure; said valves have the same characteristics of check valves; said elastic material can be formed by

squared or rounded rubber sheets with the proper thickness mechanically anchored on one side and left free to move on the other side.

**14.** A miniaturized expander for the miniaturized waste heat engine defined in claim 1, formed by a single stage expander wheel having at least two said nozzles positioned so that the forces caused by the expanding vapor counter balance the forces caused by said compressor wheel, or said compressor wheel and said exhaust gases wheel; said wheel can contain flexible Teflon seals connected to the edges of the blades of said wheel; said flexible seal rubs on the stator of said wheel which can be formed by Teflon as well or coated with Teflon; said flexible Teflon seal rotating and rubbing with said Teflon on the stator or casing of the wheel forms a rotating seal.

**15.** A miniaturized expander utilized in the miniaturized waste heat engine defined in claim 1, formed by multiple expander wheels with said nozzles spaced and positioned in a way that the summation of all reaction forces caused by the expanding vapor counter balance the effect of all forces caused by said compressor wheel and/or said exhaust gases wheel.

**16.** A multiple stage single expander wheel for the expander defined in claim 1, formed by a series of blades assembled on different circumferences of the same wheel; said wheel can be made of plastic, Teflon, or metal.

**17.** A complete expander device as defined in claims 1, 2, 3, 4, 5, 6, 8, 9, 11, 12, 13,14, and 15 mechanically coupled on one side to the complete body of a conventional/commercial centrifugal compressor, including casing and compressor wheel, and to the complete body of a conventional/commercial turbo device including casing and exhaust gases wheel on the other side, thereby forming a complete miniaturized oxygenator utilized by the waste heat engine defined in claim 1.

**18.** A complete expander device as defined in claims 1, 2, 3, 4, 5, 6, 8, 9, 11, 12, 13,14, and 15 mechanically coupled with a conventional/commercial centrifugal compressor on one side and thermally sealed on the other side, thereby forming a complete oxygenator as defined in claim 1.

**19.** A specialized waste heat recovery and power conversion plant forming the miniaturized waste heat engine defined in claim 1; said plant is formed by thermally insulated hydraulic

piping and connections; said hydraulic piping connects regulating valves to said expanders defined in claims 1, 2, 3, 4, 5, 6, 8, 9, 11, 12, 13, 14, 15, 17, and 18; said power conversion plant is characterized by a pump, a check valve injector, one or more heat converters connected in series or parallel, a three-way valve or multiple valves, a valve system connected to an excess vapor accumulation tank, one or more pressure and temperature sensors penetrating inside said converter as defined in claim 34, and one or more imploding or condensing means; said hydraulic piping is formed by semi-flexible piping material capable of withstanding the pressure fluctuations developed by the converters and which do not contain zirconium or other elements which could react with the waste heat engine working fluid; said hydraulic piping is also equipped with a pressure release valve; said working fluid circulates inside said hydraulic piping in parts due to its own expansion inside the converters and in parts due to the action of said pump; the overall mass flow rate of said working fluid is monitored and controlled by said computer; said working fluid is always circulating inside the closed loop formed by said hydraulic piping and connections; said working fluid can be distilled deionized water or other fluids even with lower vapor pressures than that shown by water; said working fluid condenses through a radiator or through imploding chambers as defined in claim 9.

**20.** Compact heat converter utilized for the waste heat engine as defined in claim 1; said compact converter is formed by a structure in thermal contact with the exhaust gas manifolds of an internal combustion engine or any heat source, said converter is formed by coils welded on the metal of the exhaust manifolds or it is formed by a heat chamber, or chambers, whose internal surfaces are in thermal contact with the exhaust gases; said compact converter can be wrapped with thermally insulating materials, or it can be positioned inside a box-like surrounding thermal container which does not favor air circulation; said compact converter can also be formed by channels internally positioned inside the exhaust gas manifolds such that said working fluid cannot enter in physical contact with the exhaust gases, but it can receive heat from the exhaust gases.

**21.** Thermal container surrounding the heat converter defined in claim 20; said thermal container is characterized by an automatically or manually movable fin structure which during normal operation traps air thermally insulating said heat converter, or it favors the circulation of cooling air when the fin structure is open, thereby exposing said converter to the surrounding environment.

22. Miniaturized waste heat engine utilizing any waste heat source as defined in claim 1 and operated in a pulsed or continuous manner by actuators means controlled by said computer; said waste heat engine is formed by the hydraulic piping and connection system described in claim 19; said waste heat engine can be set to operate its expander(s), or work producing units at constant RpM, or in a pulsed manner; said waste heat engine is characterized by a closed loop thermodynamic cycle whose operation is based on a given mass of working fluid in the absence of non condensable gases; said mass of working fluid is regulated by a pump controlled by a computer so that said pump output is characterized by a constant mass flow rate, or by pulsed mass flow rates; said pump can also be operated continuously by a mechanical link with the engine or the plant that generates the waste heat; said waste heat engine utilizes at least one expander to produce useful mechanical energy, or at least one oxygenator and utilize the remaining useful mechanical energy for electric production or as a power unit directly or indirectly coupled to the load; said power unit is formed by an expander wheel coupled to a flywheel or forming a flywheel; said waste heat engine regulates the power of its expanders by means of a three-way valve or multiple valves; said waste heat engine produces excess energy in the form of vapor which can be accumulated inside a specially thermally insulated pressure tank; said pressure tank provides boost pressures for pulsed operation of said waste heat engine.

23. Specialized waste heat engine computer as described in claim 1; said computer can optimize the cycle of said waste heat engine in real time, or it can regulate the activation or deactivation of various mechanical, electrical, hydraulic or pneumatic actuators which can regulate said working fluid mass flow rate in a coarse manner; said computer can be formed by various specialized sub-computers connected to said computer; said sub-computers can be pressure, temperature, mass flow rate controllers specialized to operate on said expander, said converter, said imploder of said waste heat engine; said computer system monitors the thermodynamic state of said working fluid by temperature and pressure probes inserted inside said converters and said expanders, it also monitors and controls the speed of said expander wheels or the expander flywheel of the power unit through speed detectors and actuators that change the position of said needles as defined in claim 2.

24. Computer controlling and optimizing the operation of the waste heat engine as defined in claims 1, 22, and 23; said computer can be formed by a specialized user programmable microprocessor which customizes the operation of the waste heat engine; said microprocessor can be programmed to use said accumulation pressure tank or utilize excess energy by expanding vapor into said expander flywheel; said computer utilizes electronic signals provided

by the probes positioned inside said expander, and said converters and sets the opening/closing of said three-way valve accordingly; said microprocessor can be programmed to close all of the vapor valves regulating the vapor admission to the various converters and re-set them open when the pressure inside said converters reaches a desired level and the accelerator of the combustion engine is pressed; said microprocessor can be programmed to pulse the pressure so as to provide boost power at the shafts of said waste heat engine's expander(s); said microprocessor can also set said fins of said thermal container defined in claim 21 open in case of malfunctioning of said hydraulic piping and connections forming said waste heat engine.

**25.** Pressure accumulating tank as defined in claim 1 with thermal insulation formed by a vacuum by means of a valve; said pressure tank accumulates excess vapor energy by inlet outlet valves controlled by said computer defined in claim 23 and 24.

**26.** Expander flywheel or power unit as defined in claim 1; said expander flywheel is formed by a heavy expander wheel or an expander wheel coupled with a flywheel; said heavy expander wheel has blades on its circumference for the transfer of energy from said superheated vapor energy to mechanical energy; said expander flywheel utilizes excess energy produced by said waste heat engine or it utilizes energy previously accumulated in said pressure accumulating tank as defined in claim 25; said flywheel is coupled to the load through a flange and a special clutch controlled and activated by said computer defined in claim 23 and 24, or by a specialized sub-computer system; said expander flywheel can be coupled directly to the load or it can utilize gear reduction mechanisms to match said expander flywheel speed with the speed of said load; said coupling clutch can be centrifugal, hydraulic, or electro-mechanical; said expander flywheel is integrated inside a casing which contains nozzles and sensors.

**27.** Coupling flange as described in the power unit of claim 26; said flange is shaped to accommodate for mechanical coupling with most common pulleys.

**28.** Expander flywheel casing with universal connections to the engine block for easy assembly and integration with a commercial internal combustion engine as described in claim 26; said casing contains said clutch, said gear reduction system, bearings, speed sensors, nozzles paths, vapor inlet ports, condensate discharge ports, and imploding chambers or steam expansion chambers; said casing is made of particularly resistant material and provides flanges which allow mechanical assembly on the frame or body of the engine to which the power unit is applied.



**29.** Oxygenator formed by a miniaturized expander and a compressor wheel and casing as described in claims 1, 2, 3, 4, 5, 6, 12, and 13; said oxygenator has at least one outlet flange allowing a sealed connection with the inlet conduit of a conventional air filter casing.

**30.** Oxygenator as described in claims 1, 2, 3, 4, 5, 6, 12, 13, and 29 in which its outlet flange allows the connection of a converging nozzle positioned inside the air flow path of a conventional air intake manifold so as to form a pressurizing jet stream.

**31.** Converging nozzle for the oxygenator described in claim 30, shaped in a way that low pressure forms on the outside surfaces of said converging nozzle and high pressure forms inside the intake air manifold.

**32.** Oxygenator as described in claim 29 and 30 in which the inlet air is filtered by an independent air filter.

**33.** Universal heat converter for the waste heat engine described in claim 1; said universal heat converter is formed by a muffler-like converter; said converter is symmetrical and has seals and flanges which allow easy assembly and connection with standard muffler piping of a combustion engine; said universal converter is formed by concentric tubes forming a chamber between the two, said chamber is sealed at its ends; the inner tube of said converter allows the passage of exhaust gases; said chamber has inlet and outlet ports allowing the connection of hydraulic piping and sensors; said chamber allows the passage of said working fluid making it expand; said expansion is a function of the heat transfer between the inner tube and the surfaces of said chamber; said chamber includes fins which create a prolonged path for said working fluid; said fins can create a spiral/elicoidal path; said fins can create open compartments hydraulically connected; said universal converters can be connected in series or in parallel forming a bank of converters.

**34.** Inlet/outlet ports for the universal heat converter described in claim 33; said ports allow easy connection of the hydraulic piping system of said waste heat engine to said universal converter; said ports are positioned on the flanges sealing said chamber formed by said inner and outer tubes; said ports are welded or screwed and sealed onto the flange and allow also sealed penetration of probes or sensors.

35. Vacuum insulation for the universal converter described in claim 33; said universal converter is thermally insulated by an additional chamber formed by another outermost cylinder sealed to the end flanges; said outermost cylinder contains a vacuum valve.

36. Universal joints for the universal converters described in claim 33; said universal joints have seals and flanges that connects with the inlet/outlet tube of said universal converter; said universal joints can form a sealed connection by inserting one side of it onto a conventional muffler piping while the other side seals and connects the inlet of said universal converter; said joints have a discharge valve; said joints can have inlet and outlet forming different angle between themselves to favor connection with multiple said universal converter(s).